Crinoids from the Silurian of Western Ohio and Indiana

Senior Research Thesis

Submitted in partial fulfillment of the requirements for graduation *with research distinction* in Earth Sciences in the undergraduate colleges of The Ohio State University

By

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Abstract:

A large section of the stratigraphic column of the Great Lakes Area is composed of carbonate rock from the Silurian Period (ca. 443-419 Ma). This limestone, which has been highly dolomitized, formed in association with an ancient reef system that was present in the epicontinental seas that prevailed during this time. The rock has been thoroughly studied for both economic and academic purposes. Silurian dolomites are used for industrial purposes, and they are a key oil producer. Study of these carbonate rock has also revealed much about the nature of ancient reef systems.

However, there is still much to learn about these reef systems. Of particular interest is the biota that helped to form the reefs. Among the least understood Silurian reef contributors are the echinoderms, in particular the crinoids. Little research has been done on Silurian reef crinoids; the last major work was in 1900. This is in part due to the high dolomitization of the fossils that makes identification of these species more difficult. To develop a better understanding of these species, a systematic study is being undertaken to identify several specimens from five different quarries in the western Ohio and Indiana.

The study of these crinoids has led to further advances in the understanding of Silurian reefs worldwide. Understanding these crinoids provides further insight into the phylogenetic history of the crinoid class, allowing also for a greater understanding of echinoderm evolution. The identification of these Silurian crinoids also aids in understanding of the organisms and the processes by which these reefs formed. There is much to be discovered yet in the Silurian reefs of the Great Lakes Area, and the identification of these crinoid species is a step toward more complete understanding.

Acknowledgements

I would like to thank and acknowledge Dr. Charles Ciampaglio of Wright State University for allowing me the use of his samples for this study, and Dr. William Ausich for his role as my research advisor, and for all of the support and help he gave me throughout the project. I would also like to thank Dr. Anne Carey and Dr. Lawrence Krissek for their advice in writing this thesis.

Introduction:

During the Silurian Period, the landscape of western Ohio and Indiana looked vastly different in comparison to today. A massive epicontinental sea completely engulfed the Great Lakes Area. During this time, a huge reef system formed in western Ohio and Indiana that supported a highly diverse fauna (fig. 1). The carbonate rock, which has been highly dolomitized, has been well studied for its industrial uses. It was used in the burned lime industry which in the past was very important, for crushed stone, and for the rock's chemical properties (Shaver et al., 1978). As a byproduct of research for economic purposes, many scientific discoveries have also been made to better understand Silurian reefs. Continued study has revealed much about the Silurian reefs of western Ohio and Indiana and the rock it resides in.

Understanding of the stratigraphy has provided insight into the depositional environments present during the Silurian. Many studies have also been done on the different faunal constituents of the reefs. However, little is known about the echinoderm constituents of the reef, in particular the stalked echinoderms. Although paleontologists understand the general role stalked echinoderms played in the development of the reef, we still know very little about the individual crinoid species and the overall diversity of the echinoderms of the reefs (Shaver, 1974). In order to learn more of both the crinoids and their diversity, it is necessary to be able to identify individual crinoid species from the reef.

This study involved an examination and identification of seventy-five specimens from five different quarries from western Ohio and Indiana. In doing this study, I identified seven species of crinoid representing three genera and also identified a single genus of cystoid.

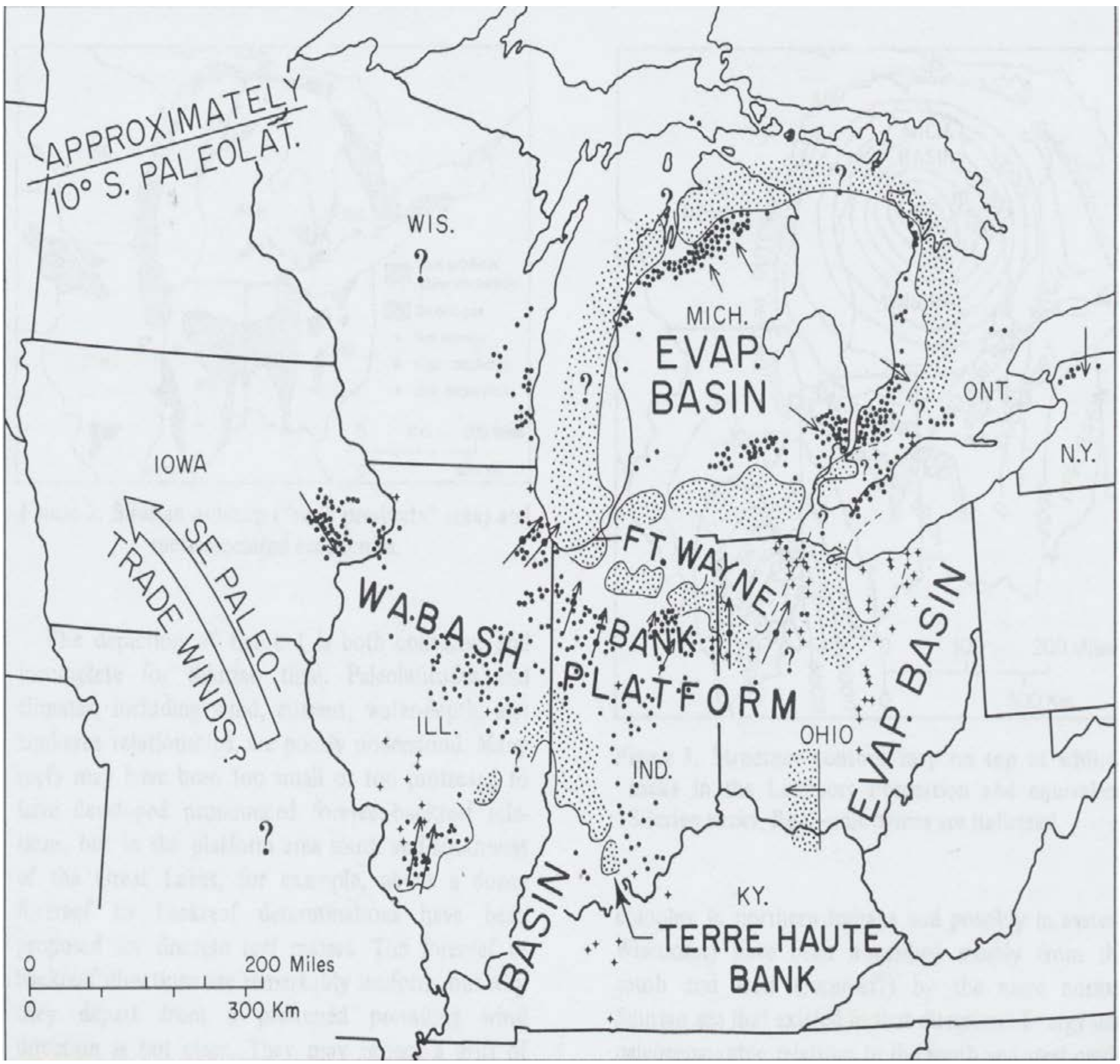

Figure 1: Map showing the known reef locations of the Great lakes area. The stippled patterns are barrier reefs, while the individual dots are patch reefs (Shaver et al., 1978).

Stratigraphy:

The reefs of Silurian age occur in six different stratigraphic intervals. The earliest reefs began in the Brassfield Limestone (Llandovery) through the Liston Creek member of the Wabash Formation. The layers are made up predominantly of limestone and dolomite, but study of each reveals slight variations in lithology, principally caused by changes in the depositional environments. During the Silurian, Ohio and Indiana were covered by an epeiric sea. However, over the course of the Silurian, there were several changes in sea level that led to slightly different lithologies and changes in the fauna present in the reefs at a given time. These differences allow for distinction among the different stratigraphic layers of the rock in western Ohio and Indiana and give us an image of the paleoenvironment at the time of deposition.

Salamonie Dolomite

The Salamonie Dolomite is the oldest formation of the five post-Llandovery reef-bearing units from the Silurian of western Ohio and Indiana. As the name suggests, the rock layer is predominantly high purity dolomite, varying in color among buff, gray, and white. The rock is thickly bedded, vuggy, and contains low angle cross-bedding on a large scale. Large portions of the dolomite are oolitic or pelletal, and abundant fossils occur, including biostromal and coquinal masses. The majority of the reefs in this formation are small incipient reefs, spreading laterally over only a few tens of feet and vertically to heights of about twenty feet. Whereas most of the reefs grew only to just below the bottom of the Waldron Formation, some of the reefs grew into the Waldron and occasionally into the lower part of the Louisville Formation. The rock and fossils suggest a fairly high-energy area over a shallow shelf as the depositional environment (Shaver 1974).

Waldron Formation

The Waldron is a relatively thin formation in the Silurian made up of five to ten feet of highly variable facies of dolomite. These different facies of dolomite can range from fine grained material to dense slabs, and from nodular argillaceous to shaly rock. In southern Indiana, the Waldron is primarily shale. The Waldron is largely without fossils except in the incipient reefs, which are probably continuations of reefs that began forming in the Salamonie. The Waldron marks a regional tectonic or epeirogenic event that created a calmer and most likely deeper depositional environment (Shaver 1974).

Louisville Limestone

The Louisville Limestone is a section that stretches from 60 to greater than 100 ft and is made up of dolomite and sporadic limestone. The facies are variable, ranging from argillaceous rock similar to the Waldron Formation, to bioclastic, slabby-bedded material similar to the younger Liston Creek Formation. The Louisville is known to contain reefs, but these reefs are most likely reefs that have continued up from the Salamonie and the Waldron. Fossils are fairly abundant within the Louisville, including some echinoderms. The depositional environment of the Louisville seems to have changed with time from the deeper and calmer waters of the Waldron to a shallower, higher energy environment, very similar to the Salamonie.

Mississinewa Shale

The oldest member of the Wabash Formation, this interreef facies varies vertically from one hundred to two hundred feet of silty, argillaceous, massive dolomite, with some minor limestone. The Mississinewa has several reefs located partially within it, although there is little evidence of reef origins being within the Mississinewa itself. This member exhibits the greatest differences between the interreef and reef environments. The interreef areas represent the greatest depths achieved by the epicontinental seas during the Silurian, as well as the calmest depositional environment. Because of this calm environment, there are very few skeletal grains in the interreef; instead, the sediment is in part terrigenous. The reefs themselves show evidence of a greater depth, because they have a very large amount of vertical growth. This vertical growth could also be evidence for a gradual shift to a deeper water environment, which is further backed by the occurrence of several locations within the interreef rock of transitional lithologies that extend for twenty feet vertically (Shaver, 1974). The Mississinewa has produced many fossils, particularly on the reefs. These reefs belong to a group known as the Huntington lithofacies, which are the reefs and reef flanks from the Louisville Limestone and the Wabash Formation.

Liston Creek Limestone Member

The last of the Silurian reef-bearing stratigraphic units is the Liston Creek Limestone member of the upper Wabash Formation. This formation has a large interreef section of fine- to medium- grained slabby-beds of cherty limestone and dolomite. However, this lithology is in some places complexly intercalated with the Mississinewa lithology. The Huntington lithofacies make up an even larger amount of the rock here than in either the Mississinewa or the Louisville. The Liston Creek contains even more fossils than the Mississinewa and has an increase in the number of organisms with strong skeletal habits inhabiting the interreef areas. This increased presence in the interreef area along with the carbonate sand and silt constituents suggest that the depositional environment of the Liston Creek was in shallower, higher energy water than during the deposition of the Mississinewa. The change in depositional environment could have been biologically mediated due to growth of the reefs and not due instead to a tectonic or epeirogenic event (Shaver, 1974).

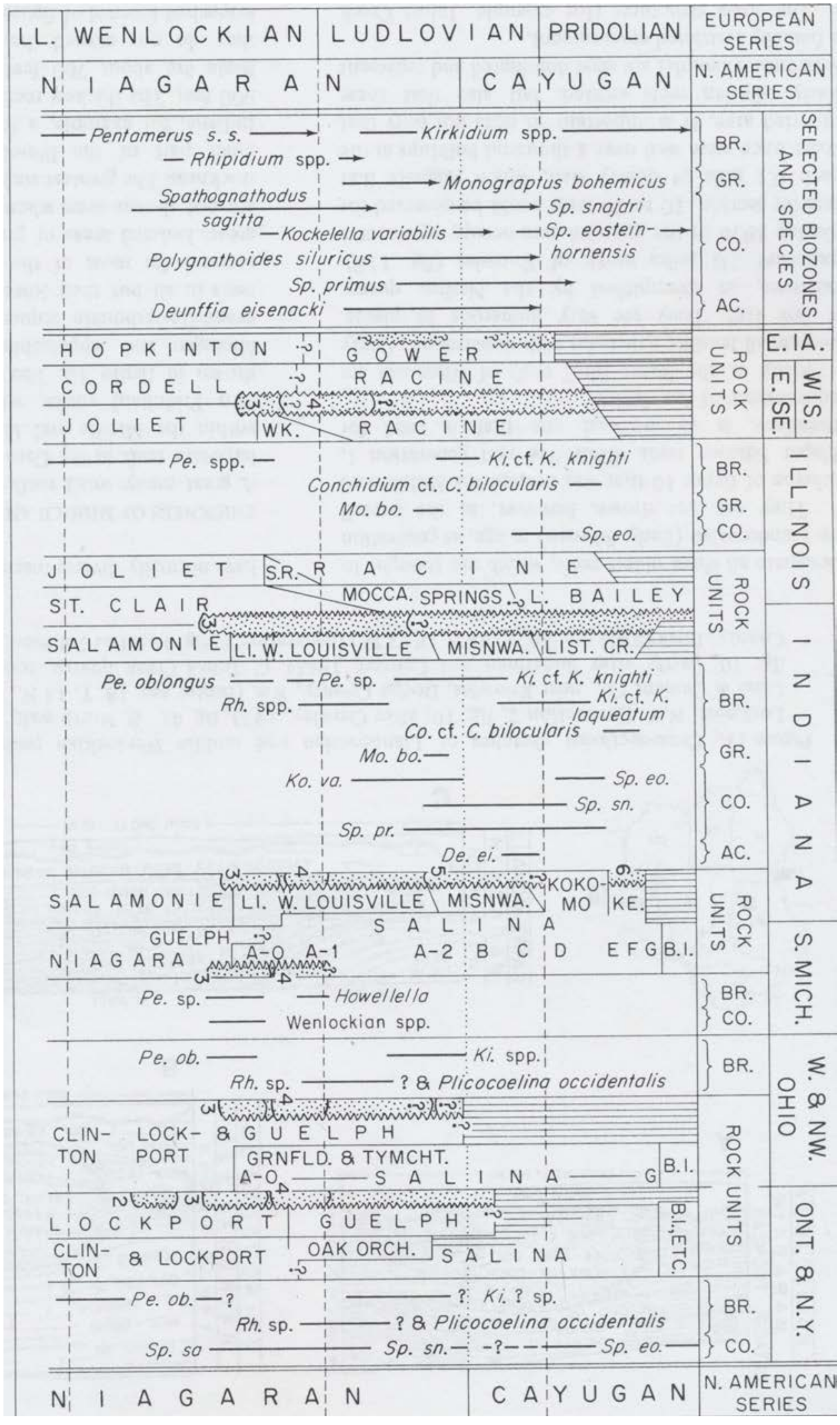

Figure 2: General stratigraphy of the Great Lakes Area (Shaver et al., 1978)

Main Reef Constituents

There are two main faunal groups within the Silurian, the reef-related species and the interreef or non-reef species. While there is some overlap between the reef and interreef species, the two groups have a trend of mutual exclusivity with stratigraphic succession, which then began to reverse with reef maturity. The trend starts in the Salamonie, where all of the fauna are non-reef, and reaches its maximum exclusivity during the Mississinewa, where only thirteen percent of the reef species and twenty percent of the interreef species overlap. After the Mississinewa, the reefs begin to show continual maturity and the trend begins to reverse, with the twenty-four percent of the reef species and fifty-four percent of the inter-reef fauna overlapping during the Liston Creek (Shaver, 1974).

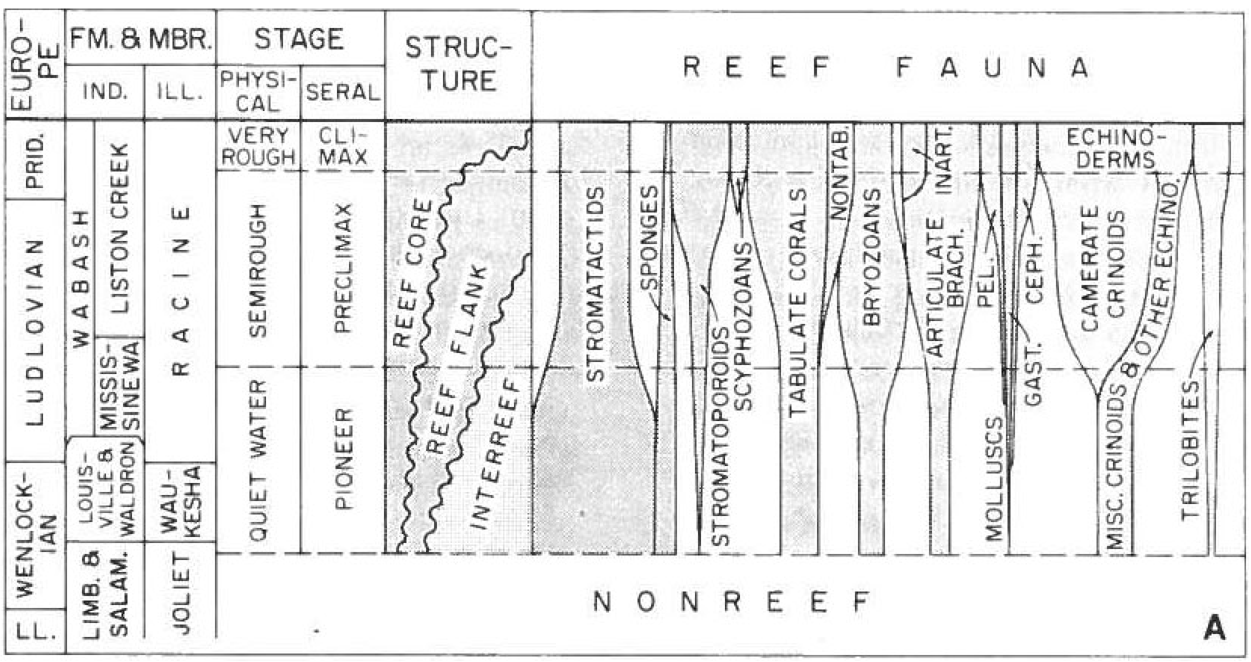

Figure 3: This diagram shows the relative volume of the Fossil Constituents of the reef (Shaver, 1974; Shaver et al., 1978).

The reef fauna can be separated further into two groups, the reef builders and the reef dwellers. The reef builders primarily include stromatoporoids, corals, and bryozoans, and they maintained the same relative level of diversity through the Silurian of the region (Fig 4).

Meanwhile, the reef dwellers, which include the brachiopods, mollusks, and echinoderms, nearly doubled in diversity from early to late in the Silurian reef succession due to the maturation of reefs. The evidence for this increase in diversity is most obvious in the brachiopods and the mollusks, although the echinoderms seem to keep relatively the same diversity. However, this does not reflect the large number of crinoid species that as yet remain unknown (Shaver 1974). It is in part for this reason that I am undertaking this study.

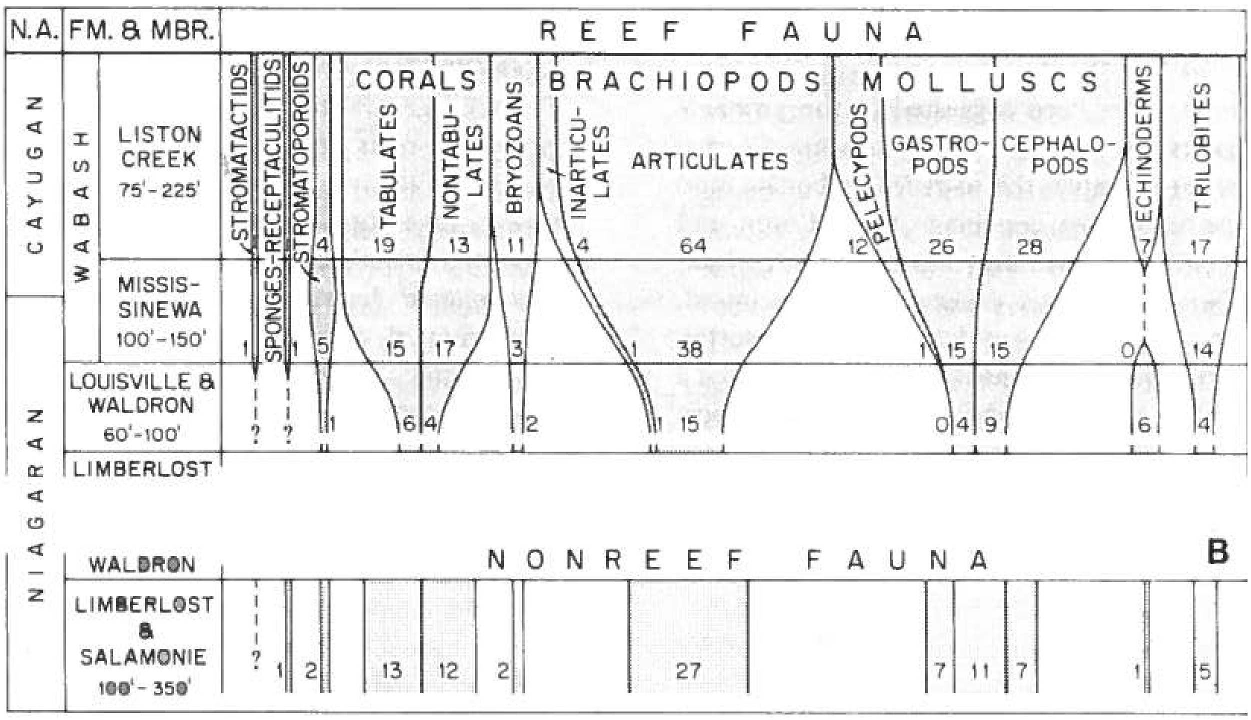

Figure 4: This diagram shows the change in diversity of the reef species from Indiana (Shaver, 1974; Shaver et al 1976).

Systematic Paleontology

In the course of the study, seventy-five specimens were studied from five different quarries from Western Ohio and Indiana. These include sixty specimens from the Poeppleman Quarry; seven specimens from Spring Creek Quarry in Sydney, Ohio; four from Barrett Quarry in Richmond, Indiana; three from Karch Quarry; and one specimen from the Ludlow Falls quarry. These specimens were sorted by quarry and then by species (Table 1) and identified based on characteristics described by Stuart Weller in *The Crinoidea* from 1900, verified using Ubaghs (1978) and other sources. In doing so, seven distinct species of crinoid from three distinct genera were identified. A single genus of cystoids, a distant relative of crinoids, was also identified.

Taxa\Quarry	Barrett	Ludlow	Karch	Poeppleman	Spring Creek
Eucalyptocrinites crassus	0	1	0	0	0
Eucalyptocrinites turbinatus	0	0	0	20	1
Periechocrinus marcouanus	0	0	0	23	0
Periechocrinus necis	4	0	0	4	0
Periechocrinus urniformis	0	0	0	3	0
Periechocrinus egani	0	0	0	4	0
Periechocrinus sp.	0	0	0	0	1
Stiptocrinus chicagoensis	0	0	2	3	0
Stiptocrinus sp.	0	0	0	0	1
Caryocrinites sp.	0	0	1	4	4

Table 1: This table shows the number of each species found within each quarry.

Class Crinoidea Miller, 1821

Subclass Camerata Wachsmuth and Springer, 1885

Order Monobathrida Moore and Laudon, 1943

Suborder Glyptocrinina Moore, 1952

Superfamily Eucalyptocrinitacea Roemer, 1856

Family Eucalyptocrinitidae Roemer, 1856

Genus *Eucalyptocrinites* Goldfuss, 1831

Dorsal cup contains four basal plates and five radial plates. These are followed by two primibrachials in each ray. The basals form a depressed cup, with the large radial plates forming the edges of the basal concavity. Distinctive partition plates on the tegmen for niches for the arms (Weller, 1900; Ubaghs, 1978).

Eucalyptocrinites crassus Hall, 1863

This crinoid is well known to have a large calyx. The cup is cone shaped, medium sized, with truncated edges and a large depression at the base. The sides are straight and can have some minor concavity or convexity. The basal plates are very small, and are deep within the basal cavity. In contrast the radial plates are very large, higher than wide, and form a very broad cup (Weller, 1900; Ubaghs, 1978).

Eucalyptocrinites turbinatus Miller, 1882

E. *turbinatus* has a large calyx with a large basal cavity that is moderately pentangular. The dorsal portion of the cup is medium sized and cone shaped. The sutures of the casts are defined by their angularities. The radial plates are small, wider than long. The first primibrachials are quadrangular, and the second primibrachials are hexagonal and slightly larger than the first primibrachials (Weller, 1900; Ubaghs, 1978).

Suborder Compsocrinina Ubaghs in Moore and Teichert, 1978

Superfamily Periechocrinacea Bronn, 1849

Family Periechocrinidae Bronn, 1849

Genus *Periechocrinus* Morris, 1843

Periechocrinus have large bowl or cone shaped calyxes. Plate surfaces are generally smooth, although many have ray ridges. Three basal plates form a wide columnar facet. The radial plates are long and narrow, as are the primibrachials. There are of primibrachial plates, the first of which is hexagonal and the second heptagonal. Generally, two secundibrachials follow, which then support a series of two to four tertibrachials. Hence, there are four arms per ray (Weller, 1900; Ubaghs, 1978).

Periechocrinus marcouanus Winchell and Marcy, 1866

The calyx is large and elongate, reaching its greatest width at the secundibrachials. The calyx is constricted near the base, narrowing again as it approaches the base of the arms. The three basal plates form a hexagonal shape and are fairly small. The radials and first primibrachials are fairly large, and both are hexagonally shaped. The second primibrachials are close to the same size as the first primibrachials, but these plates are heptagonal. There are two secundibrachials with the first the same size or smaller than the second primibrachials and their second smaller. The tertibrachials are small but numerous. The tegmen is covered by small polygonal plates and is nearly flat, but does possess a distinct anal ridge (Weller, 1900; Ubaghs 1978).

Periechocrinus necis Winchell and Marcy, 1866

P. *necis* is similar in shape to *P. marcouanus*, but smaller, with a small to medium to size calyx. The calyx is subcylindrical in shape and constricted around the base of the arms. The basal plates are medium sized and form an obscure hexagonal shape. Most of the calyx is made up of the radial and primibrachial plates, which are slightly wider than usual among *Periechocrinus*. There are two secundibrachials in each ray, both smaller than the primibrachials, with the second secundibrachial plate smaller than the first. The tertibrachials are even smaller, with generally two or more in each ray. A minor ridge extends the length of each ray, starting at the radials and continuing through the tertibrachials (Weller, 1900; Ubaghs, 1978).

Periechocrinus urniformis Miller, 1881

The calyx of *P. urniformis* is large and bowl shaped with the greatest width at the arm bases, which project out, and the plates generally decrease in size up the calyx. The basal plates are small, followed by radials and primibrachials that are both approximately the same size, both as wide as they are high. Two secundibrachials decrease in size up the calyx. The tertibrachials are even smaller, with at least two in each ray. Interradials form between the first primibrachials and the first secundibrachials. The first plates between the primibrachials are roughly the same size as the primibrachials, whereas the interradials between secundibrachials are intermediate in size between the first and second secundibrachials. This species has a very distinctive radial ridge that extends from the radial plates up to the base of the arms. There are two pairs of arms per ray, making a total of four for each ray (Weller, 1900; Ubaghs 1978).

Periechocrinus egani Miller, 1881

P. egani has a smaller, mildly cone shaped calyx, with its greatest width at the bases of the arms. The plates are highly convex, and unlike other *Periechocrinus*, *P. egani* has little to no ray ridges. The basal plates are wide and highly convex and form a hexagonal cup. The radials are as wide as they are high. Two primibrachials exist per ray, the first is hexagonal, higher than wide. The second primibrachial is heptagonal, as high as wide. There are two secundibrachials, both smaller than the primibrachials. The first is hexagonal, whereas the second is heptagonal. The second secundibrachial supports the tertibrachials, which are very small. The first interradials are hexagonal and roughly the same size as the first primibrachials (Weller, 1900; Ubaghs, 1978).

Genus *Stiptocrinus* Kirk, 1946

The main body of *Stiptocrinus* is predominantly made up of the dorsal cup. *Stiptocrinus* has three basal plates, moderately large for the size of the calyx. The radials are as high as wide. The primibrachials are smaller than the radials, with the second primibrachial smaller than the first. Two to three secundibrachials are present, but there are no tertibrachials. The posterior interray is very large, beginning with one very large plate and continuing with two to three plates that are smaller. The size of the interradial plates decrease distally (Weller, 1900; Kirk, 1946; Ubaghs, 1978).

Stiptocrinus chicagoensis Weller, 1900

The calyx is small and constricted at the arm bases. The calyx also has deep depressions between the arm bases, which protrude extensively in the casts. The basal plates are medium sized. The radials are higher than wide, which is unusual for *Stiptocrinus*. There are two primibrachials in each ray, the first of which is slightly smaller than the radials. The second primibrachial is smaller than the first primibrachial and is pentangular. The secundibrachials are much smaller than the primibrachials and rest on the upper edges of the primibrachials. *S. chicagoensis* has a large primanal similar in size and shape to the radial plates. This plate is followed by a row of three smaller plates, the middle of which is the smallest (Weller,1900; Kirk, 1946; Ubaghs, 1978).

Class Cystoidea Buch, 1844

Order Rhombifera Zittel, 1879

Superfamily Hemicosmitida Jaekel, 1918

Family Caryocrinitidae Bernard, 1895

Genus *Caryocrinites:* Say, 1825

Caryocrinites sp. Say, 1825

Caryocrinites has a globe shape, with a tapered base and a slightly convex "tegmen." The calyx has four basals, two of which are larger and hexagonal in shape. The other two basals are smaller and have a pentangular shape. The basals are followed by a row of six infralaterals. The shape of these infralaterals changes depending on the placement of the plates above the basals. The infralaterals above the two hexagonal basal plates are pentagonal, but the plate over either junction between a pentagonal and a hexagonal basal is heptagonal. The plate above the junction between the pentagonal basals is subhexagonal, and the final infralateral, which rests above the junction between the hexagonal basals, is also hexagonal. The next row of plates is the lateral plates, with eight plates in total. The plates are polygonal, but hard to interpret because they are slightly covered by the tegmen. The plates are highly ornamented, with ridges radiating from the center to the corner of each plate (Kesling, 1963; Kesling 1967).

Discussion

The Role of Crinoids on Reefs

While there is still much to learn about crinoids on ancient reef systems, there is a lot known. Camerate crinoids, such as the ones in this study, resided predominantly in the reef flanks rather than on the actual reefs. Camerates also tended to dwell on carbonate depositional environments, whereas the cladid and disparid crinoids preferred terreginous mud and silt habitats. The carbonate depositional environments are suggestive of higher energy environments; and the camerates, with larger, box-like theca, were better adapted than their cladid and disparid cousins to survive there (Lane, 1969).

There is also strong evidence that crinoids were large contributors of carbonate to the reef flanks. When echinoderms die, particularly the stalked echinoderms, if they are not immediately buried after death, they quickly begin to disarticulate (Lane, 1969; Shaver, 1974). As they do, many columnals from the stem and individual plates are spread over a wide area. This is mediated by the rate of sedimentation and the strength of the currents (Manten, 1970; Lane, 1969). Low sedimentation rate allows time for the ossicles to disarticulate, whereas stronger ocean currents allow for the carbonate material to be spread over a larger area. This makes crinoids a major contributor to the reef rock, particularly the rock representing the reef flanks.

Suggestions for Future Works

Some future work that could be pursued based on the work done here would involve further collection of samples from the quarries examined from here, doing further identifications, studying the diversity of the crinoids within each quarry, and study them more closely in relation to their stratigraphic position. This same work could also be done at new localities as well. Any of this work would further our understanding of the Silurian reefs.

Plate I

Figure 1

Figure 2

Figure 3

Figure 4

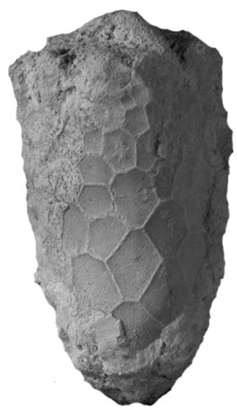

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Explanation for Plate 1:

Figure 1: Lateral view of cast of *Eucalyptocrinus crassus* showing stem, calyx, and arms.

Figure 2: Dorsal view of the calyx of *Eucalyptocrinus turbinatus*, showing the basal and radial plates.

Figure 3: Dorsal view of the calyx of the cystoid *Caryocrinites*.

Figure 4: The tegmen of *Periechocrinus marcouanus*.

Figure 5: Lateral view of the calyx of *Periechocrinus marcouanus.*

Figure 6: Lateral view of a cast of the calyx of *Periechocrinus necis*.

Figure 7: Lateral view of a cast of the calyx of *Periechocrinus egani*.

Figure 8: Lateral view of a cast of the calyx of *Periechocrinus urniformis.*

Figure 9: Lateral view of a cast of the calyx of *Stiptocrinus chicagoensis.*

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